SECTION 2

OVERVIEW OF THE NONFUEL MINING INDUSTRY

The nonfuel mining industry is an integral part of our economy. It provides a diversity of products, including the lead used in storage batteries, ammunition, and pigments; copper for electrical equipment and supplies; iron for the construction and transportation industries; zinc for galvanizing and other uses; silver for photographic materials; gold for electronic equipment, jewelry, and medicinal use; and the uranium used by electric utilities. This sector also produces nonmetallic minerals such as asbestos for use in insulating materials and phosphates used to produce industrial chemicals and fertilizers.[1] The total metal ore production in the United States was worth more than $5.8 billion, and the total value of raw nonfuel minerals was more than $21 billion in 1983.[2] This value accounted for 1 percent of the Gross National Product (GNP), while products made from these raw materials account for approximately 9 percent of the GNP annually.[3]

2.1 NONFUEL MINING SEGMENTS

There were 580 metal mines and 12,117 nonmetal mines active in 1980 (the most recent year for which complete data are available from the U.S. Bureau of Mines).[4] The number of active mines varies from year to year, depending on factors such as the level of U.S. economic activity, the costs of production in the mining industry, the demand for products derived from nonfuel minerals, and prices in international markets. In general, the number of mines in operation has decreased over the past several years; however, a reasonable estimate for 1983 indicates that between 400 and 500 metal mines operated in the segments covered here. Table 2-1 lists the number of active nonfuel mines in 1980, 1981, and 1982 for the mining industry segments covered in this report: all metal mines, except gold placer operations, appear in the metals category, and all asbestos and phosphate mines appear in the nonmetals category. The metal mining segments include copper, gold, iron ore, lead, molybdenum, silver, uranium, zinc, and a group of "other" metals. The metals in the "other" category have been grouped in order to avoid disclosing confidential business information; they include antimony, bauxite, beryllium, mercury, nickel, the rare earth metals, titanium, and vanadium. Because domestic tin and manganiferous ore mines have been minor sources of ore since 1982, these segments are not covered in this report. Platinum also is not covered in this report because no platinum mines have been active since 1982.

Although mines are classified on the basis of their predominant product, they may also produce large quantities of other materials as coproducts. For example, in 1978, U.S. zinc mines produced 72 percent of all zinc; 100 percent of all cadmium, germanium, indium, and thallium; and 3.1, 4.1, and 6.1 percent of all gold, silver, and lead mined in the United States, respectively. In the same year, copper mines produced over 30 percent of the silver, 35 percent of the gold, and 100 percent of the rhenium, selenium, palladium, tellurium, and platinum mined in this country.[5] Thus, a copper mine may also produce gold and silver as coproducts. Table 2-2 summarizes the products and coproducts for selected metal mining segments.

In most mining segments, a few large mines produce most of the product. Table 2-3 shows the number of mines in each segment, categorized by volume of material handled. This volume includes the amount of earth and rock that must be removed to reach the ore. About half of all U.S. metal mines active in 1982 were small, handling less than 10,000 tons of material each. These 213

Table 2-1 Number of Active Mines in the Industry Segments Covered in This Report in 1980, 1981, and 1982[a]

Mining industry segment	Number of mines 1980	Number of mines 1981	Number of mines 1982
Metals:			
Bauxite (alum)	10	10	8
Copper	39	44	32
Gold[b]	44	107	101
Iron ore	35	31	26
Lead	33	29	17
Silver	43	75	63
Titanium	5	5	5
Tungsten	29	29	23
Uranium	265	95	128
Zinc	20	17	14
Other metals[c]	21	18	21
Subtotal	544	560	438
Nonmetals:			
Asbestos	4	4	3
Phosphate rock	44	43	33
Subtotal	48	47	36
TOTAL	592	607	474

a Excludes wells, ponds, and pumping operations.
b Excludes placer operations.
c Includes antimony, beryllium, mercury, molybdenum, nickel, platinum, rare-earth metals, and vanadium.

Source: Adapted from BOM 1981a, BOM 1982, and BOM 1983.

Table 2-2 Product As a Percentage of Total Output for Selected U.S. Metal Mines in 1978

Primary mine product	Product or Coproduct				
	Copper	Gold	Lead	Silver	Zinc
Copper	98.8	36.7	__b	31.7	1.3
Gold	__b	55.6	__b	1.7	__b
Lead	0.8	O.1	90.3	8.7	25
Silver	0.3	4.1	3.4	53.7	0.9
Zinc	O.1	3.1	6.1	4.1	72
Total[a]	100.0	99.6	99.8	99.9	99.2

a Totals may not equal 100 percent due to rounding.

b Indicates less than 0.5 percent.

Source: Adapted from BOM 1981a.

Table 2-3 Mines in the Industry Segments Covered in this Report in 1982, by Volume of Material Handled[a,b]

Mining industry segment	Total number of mines	Less than 1,000 tons	1,000 to 10,000 tons	10,000 to 100,000 tons	100,000 to 1,000,000 tons	1,000,000 to 10,000,000 tons	More than 10,000,000 tons
Metals:							
Bauxite (aluminum)	8	--	1	5	2	--	--
Copper	32	3	1	5	1	15	7
Gold[c]	101	41	28	11	14	6	1
Iron ore	26	--	2	4	6	8	6
Lead	17	7	1	--	2	7	--
Silver	63	32	14	6	10	1	--
Titanium	5	--	--	--	1	4	--
Tungsten	23	18	2	2	1	--	--
Uranium	128	16	34	52	24	2	--
Zinc	14	--	1	2	9	2	--
Other metals[d]	21	5	7	2	2	5	--
Subtotal	438	122	91	89	72	50	14
Nonmetals:							
Asbestos	3	--	--	3	--	--	--
Phosphate rock	33	--	1	--	4	23	5
Subtotal	36	--	1	3	4	23	5
TOTAL	474	122	92	92	76	73	19

a Includes product and waste, but excludes wells, ponds, and pumping operations.
b These data are reported in short tons; one short ton equals 1.1 metric tons.
c Excludes placer operations.
d Includes antimony, beryllium, mercury, molybdenum, nickel, rare-earth metals, and vanadium

Source: BOM 1981a.

small mines handled only 10 percent of the material handled by the 14 largest mines.

2.2 GEOGRAPHIC DISTRIBUTION OF MINES

Because ores occur only in certain geologic formations, most of the mining in each industry segment is concentrated in a few locations. Copper mining is centered in three states: Arizona, Utah, and New Mexico. Other states where copper is mined as a coproduct of silver, zinc, and lead production are Montana, Tennessee, and Missouri, respectively. Some copper mines and mills are close to large cities (Tucson and Salt Lake City), but most active operations are in sparsely populated (four people per square kilometer, compared with a national average of 25 people per square kilometer) parts of Arizona.

Nevada, South Dakota, and Montana were responsible for 85 percent of the primary gold production in 1983 (excluding gold produced by Alaskan placer operations). Other primary gold-producing states are California, Colorado, Idaho, New Mexico, and Utah. Gold is also produced as a coproduct of silver and copper mining in Utah, Nevada, and Arizona. Placer mines in Alaska and gold heap leaching operations in Nevada are located in areas far removed from population centers.

Almost all iron ore is mined in Minnesota and Michigan, although Texas, Missouri, Utah, Wyoming, and California combined are responsible for approximately 5 percent of all iron ore production. Primary lead production in the United States is confined to Missouri, where lead mining is concentrated in the Mark Twain National Forest (the average population density in the southeastern part of the state is five people per square kilometer). Lead is also recovered as a coproduct from some western mining operations. Colorado is the primary molybdenum-producing state. Although silver is mined in many states, its production as a primary metal is concentrated in sparsely populated areas of Idaho, Montana, Nevada, and Utah. Primary silver production accounted for 70 percent of U.S. silver output in 1983, an increase of 54 percent since 1978 (see Table 2-2). The remainder was produced as a coproduct of copper, gold, lead, and other metals mining activities.

Uranium mining is concentrated in sparsely populated parts of New Mexico, Wyoming, Colorado, and Utah. Zinc is produced in Tennessee, New York, Missouri, New Jersey, Idaho, and Colorado; Missouri produces 21 percent of all U.S. zinc as a coproduct of lead production. Zinc is also a coproduct of silver production. Zinc mining in Tennessee and New York is located in moderately populated areas (45 people per square kilometer in Tennessee and 16 people per square kilometer in New York). The largest Tennessee zinc mining district is 50 kilometers from Knoxville.

The mining of metals in the other metals category is generally restricted to the metal ore-producing states mentioned above. Additionally, California produces tungsten and rare earth metals, and Arkansas produces bauxite for metallurgical uses.

Asbestos mining is restricted to California and Vermont. The asbestos mine in Vermont and one of the mines in California are in areas of moderate population density. Phosphate mining is concentrated in Florida, North Carolina, and Idaho. In Idaho, phosphate mining occurs in a sparsely populated area; but in Florida, most phosphate operations are about 65 kilometers east of Tampa, in an area with a population density of 68 people per square kilometer. Table 2-4 summarizes the number of operating mines and percentage of 1983 production in each state, arranged by EPA region, for the nonfuel mining segments covered in this report. Note that for some products, a few mines are responsible for the majority of all primary production. For

Table 2-4 Active Mines and Percentage of Production by State[a] in 1983.

States arranged by EPA region	Copper	Gold[b]	Iron ore	Lead	Molybdenum	Silver	Uranium	Zinc	Asbestos	Phosphate
I										
Vermont	--	--	--	--	--	--	--	--	1(25)	--
II										
New Jersey	--	--	--	--	--	--	--	1(8)	--	--
New York	--	--	--	--	--	--	--	2(27)	--	--
III										
Pennsylvania	--	--	--	--	--	--	--	1(8)	--	--
IV										
Florida	--	--	--	--	--	--	--	--	--	20(74)
N. Carolina	--	--	--	--	--	--	--	--	--	1(11)
Tennessee	1(1)	--	--	--	--	--	--	7(51)	--	4(3)
V										
Michigan	--	--	2(25)	--	--	--	--	--	--	--
Minnesota	--	--	9(70)	--	--	--	--	--	--	--
VI										
N, Mexico	2(11)	6(3)	--	--	--	5(1)	20(25)	--	--	--
Texas	--	--	2(1)	--	--	--	6(5)	--	--	--
VII										
Missouri	--	--	1(2)	7(100)	--	--	--	--	--	--
VIII										
Colorado	--	20(4)	--	--	2(100)	5(6)	28(15)	1(6)	--	--
Montana	1(3)	16(10)	--	--	--	9(17)	--	--	--	1(1)
S.Dakota	--	1(19)	--	--	--	--	--	--	--	
Utah	1(17)	1(2)	3(1)	--	--	3(8)	23(13)	--	--	1(1)
Wyoming	--	--	2(1)	--	--	--	22(40)	--	--	--

Table 2-4 (Continued)[a]

States arranged by EPA region	Copper	Gold[b]	Iron ore	Lead	Molybdenum	Silver	Uranium	Zinc	Asbestos	Phosphate
IX										
Arizona	20(68)	4(<1)	--	--	--	7(<1)	--	--	--	--
California	--	16(2)	1(4)	--	--	1(1)	--	--	--	--
Nevada	--	45(56)	--	--	--	10(14)	--	--	--	--
X										
Alaska	--	--	--	--	--	--	--	--	--	--
Idaho	--	8(3)	--	--	--	11(55)	--	--	--	5(11)
Washington	--	--	--	--	--	--	1(3)	--	--	--
TOTAL NUMBER OF MINES	25(100)	117[b](100)	20(100)	7(100)	2[c](100)	51(100)	100(100)	12(100)	3(100)	32(100)

a Numbers in parentheses represent the percentage of primary product production. Percentages may not add to 100 because of rounding.
b Excludes placer operations.
c 1982 data.

Source: Charles River Associates 1985, based on data from BOM.

example, two mines produce 75 percent of all U.S. asbestos, nine mines produce 70 percent of all iron ore, and seven mines are responsible for all lead ore production.

2.3 MINING AND BENEFICIATION WASTES

In the nonfuel mining industry, the valuable portion of the crude ore is a small fraction of the total volume of material that must be handled to obtain it (Table 2-5). For example, over 6,900 units of material must be handled to obtain one marketable unit of uranium. The high ratio of "material handled" to "marketable product" is due primarily to the low percentage of metal in the ore and to the mining methods and processes that must be employed. As shown in Table 2-5, no metal exceeds 5 percent of the crude ore in which it is embedded, except iron. Aluminum in metallurgical bauxite presents a similar picture. As high-grade ore reserves continue to dwindle, these percentages are likely to become even smaller. The fact that the materials handled consist largely of waste or unusable materials distinguishes these mining industry segments from many other process industries where waste materials make up a relatively small portion of the materials processed to produce a final product.

Several stages in the production of valuable products from minerals and ores require the handling of large volumes of material, much of which is waste. Overburden and waste rock must be removed to expose the ore. The ores are then extracted (mined) and then transported to a nearby mill, where they are beneficiated (concentrated or dressed). Mining and beneficiation processes generate four categories of large-volume waste: mine waste, tailings, dump and heap leach waste, and mine water.

Mining includes a variety of surface and underground procedures. Surface

Table 2-5 Ratio of Material Handled to Units of Marketable Metal and Estimated Percentage of Metals in Ore

Mining industry segment	Ratio of material handled to units of marketable metal [a,b]	Typical percentage of metal in ore[c]
Copper	420: 1	O. 6
Gold	350,000: 1	O. 0004
Iron ore	6:1	33.0
Lead	19:1	5.0
Mercury	NA	O.5
Molybdenum	NA	O.2
Silver	7,500: 1	0.03
Tungsten	NA	0.5
Uranium	6900: 1	O.15
Zinc	27:1	3.7

NA indicates not avail able.
a Excludes material from development and exploration activities.

Source: bBOM 1983, and c estimated by Charles River Associates 1985.

mining methods include quarrying, and open-pit, open-cut, open-cast, dredging, and strip mining. Underground mining creates adits (horizontal passages) or shafts by room-and-pillar, block caving, timbered stope, open stope, and other methods. Hydrometallurgical processes include heap, dump, vat, and in situ leach methods. (See Appendix D, Glossary, for a description of mining methods.) The vast majority of nonfuel ores are mined on the surface. Only antimony, lead, and zinc mining are solely underground operations. As shown in Table 2-6, the industry segments that employ both methods handled more ore in surface mines than in below-ground mines (with the exception of silver) in 1982.[6]

Surface mining generates more waste than underground mining. Table 2-7 compares the waste and crude ore handled by the industry segments that mine both above and below ground. (Reliable data were not available for iron ore.) As shown, the volume of waste as a percentage of the total amount of crude ore ranges from 9 to 27 percent for underground mines. In surface mining, the amount of waste ranges from 2 to 10 times the total volume of crude ore. Gold surface mining creates nearly 12 times as much waste per unit of ore as underground gold mining; silver generates 59 times as much. All mining methods used by the industry segments covered in this report generate mine waste. It should be emphasized, though, that the typical percentage of metal in an ore (excluding overburden and waste rock) is usually very low (from a few percent to a fraction of a percent).

Mine waste is the soil or rock that mining operations generate during the process of gaining access to an ore or mineral body, and includes the overburden consolidated or unconsolidated material overlying the mined area) from surface mines, underground mine development rock (rock removed while sinking shafts, accessing, or exploiting the ore body), and other waste rock,

Table 2-6 Percentage of Crude Ore Handled at Surface and Underground Mines in 1982, by Commodity

Mining industry segment	Surface mines	Underground mines
Metal s:		
Antimony	--	100.0
Bauxite (aluminum)	100.0	--
Beryllium	100.0	--
Copper	87.6	12.4
Gold[a]	92.0	8.0
Iron ore	98.9	1.1
Lead	--	100.0
Mercury	100.0	--
Molybdenum	100.0[b]	W
Nickel	100.0	--
Rare earth metals	100.0	--
Silver	36.0	64.0
Titanium	100.0	--
Tungsten	W	100. O[c]
Uranium	68.8	31.2
Vanadium	100.0	--
Zinc	--	100.O
Average percent mined	69.7	30.4
Nonmetal s:		
Asbestos	100.0	--
Phosphate rock	100.0[b]	--
Average percent mined	100.0	0
Average percent mined, metals and nonmetals	72.8	27.2

W indicates information withheld by Bureau of Mines to protect confidential business information.
a Excludes placer operations.
b Includes underground operations; the Bureau of Mines does not publish these data separately.
c Includes surface operations; the Bureau of Mines does not publish these data separately.

Source: Adapted from BOM 1983.

Table 2-7 Material Handled at Surface and Underground Mines in 1982, for Selected Industry Segments (in thousands of metric tons)

	Surface			Underground		
Mining industry segment	Crude ore	Waste	Waste/ crude ore ratio	Crude ore	Waste	Waste/ crude ore ratio
Copper	156,004	321,985	2.06	22,040	1,968	0.09
Gold	21,768	48,797	2.24	1,896	369	0.19
Silver	2,186	19,319	8.84	3,891	584	0.15
Uranium	6,848	72,197	10.54	3,111	848	0.27

Source: Adapted from BOM 1983.

including the rock interbedded with the ore or mineral body. The particle size of mine waste ranges from small clay particles (0.002 mm diameter) to boulders (0.3 m diameter). Mine waste piles cover areas ranging from 2 to 240 hectares, with a mean area of 51 hectares (1 hectare equals 2.471 acres), according to a U.S. Bureau of Mines (BOM) survey of 456 waste piles in the copper, lead, zinc, gold, silver, and phosphate industry segments.[7]

After the ore is mined, the first step in beneficiation is generally grinding and crushing. The crushed ores are then concentrated to free the valuable mineral and metal particles (termed values) from the matrix of less valuable rock (called gangue). Beneficiation processes include physical/chemical separation techniques such as gravity concentration, magnetic separation, electrostatic separation, flotation, ion exchange, solvent extraction, electrowinning, precipitation, and amalgamation.[8] The choice of beneficiation process depends on properties of the metal or mineral ore and the gangue, the properties of other minerals or metals in the same ore, and the relative costs of alternative methods. All processes generate tailings, another type of waste.

Tailings are the waste materials remaining after physical or chemical beneficiation operations remove the valuable constituents from the ore. Tailings generally leave the mill as a slurry, consisting of 50 to 70 percent (by weight) liquid mill effluent and 30 to 50 percent solids (clay, silt, and sand-sized particles).

More than half of all mine tailings are disposed of in tailings ponds. Use of tailings ponds is the primary method by which wastewater is treated in the metals ore mining segment. Also, settling ponds are typically used at mineral mining and processing operations. Pond size and design vary by industry segment and mine location. Some copper tailings ponds in the southwest cover 240 to 400 hectares (one exceeds 2,000 hectares), while some small lead/zinc tailings ponds cover less than 1 hectare. Based on a BOM survey of 145 tailings ponds in the copper, lead, zinc, gold, silver, and phosphate industries, the average size of these ponds is approximately 200 hectares.[9] Many facilities use several ponds in series, which improves treatment efficiency. Multiple-pond systems offer other advantages as well, as the tailings themselves are often used to construct dams and dikes.

Technological advances since the turn of the century have made it economically feasible to beneficiate ore taken from lower-grade ore deposits (i.e., those with a much lower material-to-waste ratio)[10] For example, froth flotation beneficiation processes have had a tremendous effect on mine production and on the amount and type of mine waste generated. Not only have these advances increased mining production, but the volume of waste generated also has risen dramatically. The tailings from froth flotation operations are generally alkaline, because the froth flotation process is most efficient at a higher pH. The metals in the alkaline tailing solids are therefore often immobile, unless the conditions in the solids change over time.

Dump leaching, heap leaching and in situ leaching are other processes used to extract metals from low-grade ore. In dump leaching, the material to be leached is placed directly on the ground. Acid is applied, generally by spraying, although many sulfide ores will generate acid during wetting. As the liquid percolates through the ore, it leaches out metals, a process that may take years or decades. The leachate, "pregnant" with the valuable metals, is collected at the base of the pile and subjected to further processing to recover the metal. Dump leach piles often cover hundreds of hectares, rise to 60 meters or more, and contain tens of millions of metric tons of low-grade ore (overburden), which becomes waste after leaching. The dump leach site is often selected to take advantage of impermeable surfaces and to utilize the natural slope of ridges and valleys for the collection of pregnant leach solutions. Loss of leach solution is kept to a minimum in order to maximize metal recovery.

Heap leaching operations are much smaller than dump leach operations, generally employ a relatively impermeable pad under the leach material to maximize recovery of the leachate, and usually take place over a period of months rather than years. Heap leaching is generally used for ores of higher grade or value. For gold ore, a cyanide solution is used as a leaching solution, rather than acid. When leaching no longer produces economically attractive quantities of valuable metals, and the sites are no longer in use, the spent ore is often left in place or nearby without further treatment.

In situ leaching is employed in shattered or broken ore bodies on the surface or in old underground workings. Leach solution is applied either by piping or by percolation through overburden. Leach solution is then pumped from collection sums to a metal recovery or precipitation facility. In situ leaching is most economical when the ore body is surrounded by an impervious layer, which minimizes loss of leach solutions. However, when water is sufficient as a leach solution, in situ leaching is economical even in pervious strata.

Leaching processes are used most often in gold (cyanide leach), uranium (water leach in situ), and copper operations (sulfuric acid).

The final waste type, <u>mine water,</u> is water that infiltrates a mine and must be removed to facilitate mining. The quantity and quality of the mine water handled varies from mine to mine; quantities may range from zero to thousands of liters per ton of ore mined. The number of mine water ponds at mine sites in the industry segments covered in this report is usually between one and six.[11]

2.4 WASTE QUANTITIES

Table 2-8 presents an estimate of the cumulative amount of tailings and mine waste generated by the mining and beneficiation of metallic ores, phosphate rock, and asbestos from 1910 through 1981. As shown, nearly 49 billion metric tons of waste have been generated by the mining and beneficiation of eight metals and two nonmetals. Copper, iron ore, and phosphate rock have produced over 85 percent of the total volume of waste. Mining and beneficiating nonfuel ores and minerals generated approximately 2,000 million metric tons of waste in 1980.[12] The waste handled in the U.S. mining industry declined to 1,300 million metric tons for the industry as a whole in 1982.[13] The industry segments covered in this report are responsible for more than 90 percent of this nonfuel mining waste. The 1980 and 1982 estimated waste volumes for each segment are shown in Table 2-9. The copper mining segment alone generates approximately half of the waste produced by the metal mining segments, and one-third of the total waste. The phosphate mining industry is responsible for almost all waste from the nonmetal mining segments, and more than 25 percent of all mining waste discussed. Iron ore and uranium mining also generate large volumes of waste.

The waste for each mining segment is broken out by waste type for 1980 and 1982 in Tables 2-10 and 2-11, respectively. (Mine water quantities are variable and difficult to estimate accurately, and are not shown on these tables.) The waste tonnages shown in Tables 2-10 and 2-11 are estimates based on primary production data. Over half of all mining waste generated in these years was mine waste, and tailings accounted for slightly less than one-third of the total amount of waste.

The phosphate rock, uranium, copper, and iron ore mining segments were, in that order, the largest generators of mine waste in 1980, accounting for over

Table 2-8 Estimated Cumulative Mine Waste and Tailings Generated by the Mining and Beneficiation of Metallic Ores, Phosphate Rock and Asbestos, 1910 Through 1981 (millions of metric tons)

Mining industry segment	Tailings	Mine waste	Total waste
Metals:			
Copper	6,900	17,000	23,900
Gold	350	400	750
Iron ore	3,000	8,500	11,500
Lead	480	50	530
Molybdenum	500	370	870
Silver	50	30	80
Uranium	180	2,000	2,180
Zinc	730	70	800
Nonmetals:			
Phosphate rock	2,200	5,500	7,700
Asbestos	40	30	70
TOTAL	14,430	33,950	48,380

Source: Estimated by Charles River Associates 1985, based on Coppa 1984, BOM various years, and BOM 1980a.

Table 2-9 Estimated Volume of Waste Generated by the Mining and Beneficiation of Metallic Ores, Asbestos, Phosphate Rock, and Overburden From Uranium Mining[a] (millions of metric tons/year)

Mining industry segment	1980	1982
Metal s:		
Copper	723	502
Gold[b]	38	74
Iron ore	350	177
Lead	11	11
Molybdenum	46	30
Silver	13	26
Uranium (mine waste only)	298	73
Zinc[c]	6	7
Other metals[d]	29	26
Subtotal	1,514	926
Nonmetal s:		
Asbestos	7	6
Phosphate rock	500	403
Subtotal	507	409
TOTAL	2,021	1,335

a Excludes mine water.
b Excludes placer operations.
c About 4 million metric tons of saleable products are extracted before tailings disposal.
d Includes antimony, bauxite, beryllium, manganiferous ore, mercury, platinum, rare earth metals, tin, tungsten, and vanadium.

Source: Estimated by Charles River Associates 1985 based on BOM 1981a and 1983.

Table 2-10 Estimated Volume of Waste Generated by the Mining and Beneficiation of Metallic Ores, Phosphate Rock, Asbestos, and Overburden from Uranium Mining in 1980[a] (millions of metric tons)

	Waste production			
Mining industry segment	Mine waste	Tailings	Dump and heap leach wastes	Total
<u>Metal s:</u>				
Copper	282	241	200 (Dump)	723
Gold[b]	25	10	3 (Heap)	38
Iron ore	200	150	--	350
Lead	1	10	--	11
Molybdenum	16	31	--	46
Silver	10	3	<l (Heap)	13
Uranium	298	NA	--	298
Zinc	1	5c	--	6
Other metal s[d]	<u>24</u>	<u>5</u>	--	<u>29</u>
Subtotal	856	455	203	1,514
<u>Nonmetal s:</u>				
Asbestos	5	2	--	7
Phosphate rock	<u>348</u>	<u>152</u>	--	<u>500</u>
Subtotal	353	154	--	507
TOTAL	1,209	609	203	2,021

NA indicates not applicable to this report.
a Excludes mine water.
b Excludes placer operations.
c About 4 million metric tons of saleable products are extracted before tailings disposal.
d Includes antimony, bauxite, beryllium, manganiferous ore, mercury, platinum, rare-earth metal s, tin, tungsten, and vanadium.

Source: Estimated by Charles River Associates 1985 based on BOM 1981a.

Table 2-11 Estimated Volume of Waste Generated by the Mining and Beneficiation of Metallic Ores, Phosphate Rock, Asbestos, and Overburden from Uranium Mining in 1982[a] (millions of metric tons)

	Waste production			
Mining industry segment	Mine waste	Tailings	Dump and heap leach wastes	Total
Metals:				
Copper	124	178	200 (Dump)	502
Gold[b]	39	24	11 (Heap)	74
Iron ore	102	75	--	177
Lead	2	9	--	11
Molybdenum	24	6	--	30
Silver	20	6	<1(Heap)	26
Uranium	73	NA	--	73
Zinc	1	6[c]	--	7
Other metals[d]	23	3	--	26
Subtotal	408	307	211	926
Nonmetals:				
Asbestos	4	2	--	6
Phosphate rock	294	109	--	403
Subtotal	298	111	--	409
TOTAL	706	418	211	1,335

NA indicates not applicable to this report.
a Excludes mine water.
b Excludes placer operations.
c About 4 million metric tons of saleable products are extracted before tailings disposal.
d Includes antimony, bauxite, beryllium, mercury, rare earth metals, tungsten, and vanadium.

Source: Estimated by Charles River Associates 1985 based on BOM 1983.

93 percent of the total in that category. These four segments were also the largest generators of mine waste in 1982, generating nearly 84 percent of the total.

More than 89 percent of tailings wastes were generated by copper, iron ore, and phosphate rock production in 1980; this percentage was almost 87 percent in 1982. Dump and heap leaching are confined to the copper, silver, and gold segments. The gold segment generated less than 2 percent of all leaching waste in 1980, but this increased to more than 5 percent in 1982. This twofold rise in the volume of gold leaching waste was caused by an increase in the use of the heap leaching method in this segment, a trend that is likely to continue because of the increased value of the gold and the decline in prices of many other metal commodities.

The wastes generated by the nonfuel mining industry are generally disposed of on site, and thus the geographic distribution of active mining waste management sites corresponds closely to the distribution of mine sites. Transportation or treatment of these wastes beyond that practiced in connection with wastewater treatment and disposal is not commonly practiced in most segments. Accordingly, the principal mining states, i.e., Arizona (copper), Minnesota (iron ore), New Mexico and Wyoming (uranium), and Florida (phosphate rock), are the states that produce the majority of all mining waste.[14]

2.5 SUMMARY

The major categories of waste are mine waste and mine water from mining operations, dump and heap leach wastes from leaching operations, and mill tailings from the beneficiation (concentration) of ores. In situ leaching of rock or in mines is performed in place. Annual waste generation totaled 2 billion metric tons in 1980 and 1.0 billion metric tons in 1982 for the metal mining segments and the phosphate and asbestos mining industries. Several mining segments are geographically restricted: lead (100 percent in Missouri); molybdenum (100 percent in Colorado); asbestos (75 percent in California); phosphate (74 percent in Florida); iron {70 percent in Minnesota); and copper (68 percent in Arizona). In both 1980 and 1982, the three segments generating the largest amounts of waste were copper, phosphate, and iron.

SECTION 2 FOOTNOTES

1 BOM 1983.

2 BOM 1983.

3 U.S. Department of Commerce 1985.

4 All mines are not censused every year. Other mines in the nonmetals industry segments include abrasives, asphalt, barite, boron minerals, diatomite, feldspar, fluorspar, graphite, greensand marl, gypsum, kyanite, lime, mica (scrap), perlite, potassium salts, pumice, salt, sodium carbonate, stone, sulfur, talc, vermiculite, and wollastonite. Clay and sand and gravel mines accounted for approximately 95 percent of all nonmetal mines in 1982.

5 BOM 1981a.

6 See also US EPA 1982a.

7 Mountain States Research and Development, Inc. 1981.

8 Mining and beneficiation methods are discussed in detail in EPA's final Development Document for Effluent Limitations Guidelines and Standards for the Ore Mining and Dressing Point Source Category.

9 BOM 1981b.

10 Martin and Mills 1976.

11 PEDCo Environmental, Inc. 1984.

12 Charles River Associates 1984a, based on BOM 1981a.

13 BOM 1984.

14 Charles River Associates 1985a.